Homework -5 (Due on May 20, 2020)

1. Suppose n two-dimensional topological insulators are stacked atop one another. Assuming electrons can tunnel between adjacent layers, and disorder is present, for which n can you *guarantee* the existence of a conducting channel at the boundary/edge? Why?

2. Consider the simple case where spin is conserved. In the quantum spin Hall bar system as shown in the figure on the left. What happens if, instead of applying a voltage between terminals 1 and 2, you manage to apply a spin-polarized current between terminals 1 and 2? Explain why.

3. In Fig. 5 of DOI: 10.1126/science.1148047 (as shown in the middle figure), we see a suppression of conductance with magnetic field in the quantum spin Hall system. Try to explain that why did we not see a similar suppression of conductance with magnetic field in the case of the integer quantum Hall effect?

4. In an experiment when measuring the quantum Hall effect in 3D topological insulator, by which control parameter, we can remove the 0th plateau in the quantum Hall effect? Can the following parameters do this job? For example, in-plane/out-of-plane magnetic field, gate voltage, mass term, etc. Explain why.

5. Continue to Question 2 of Homework 4:

(c) Construct the representation of $\mathcal{P}$ and $\mathcal{T}$ operators for this system and show that the Hamiltonian is $\mathcal{P}$- and $\mathcal{T}$-invariant. Explain why the $\mathcal{T}$-invariance holds although the system is in external magnetic field. Would this be the case for an arbitrary p, q ?